BIOTECH, India

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the **Ashden Awards** for sustainable energy

Management of domestic and municipal waste at source produces biogas for cooking and electricity generation

Summary

BIOTECH is an NGO based in Kerala, South India, which has developed biogas digesters for managing food waste and other organic waste in 12,000 households, 220 institutions and 19 municipal sites. The digesters are prefabricated from ferro-cement and gas collectors made from Fibreglass Reinforced Plastic (FRP) so that they can be installed quickly and easily on site.

Biogas is produced from the decomposition of the organic matter in anaerobic conditions, and in households and institutions the gas is used directly for cooking, giving savings of about 50% when displacing LPG use. Some systems take waste from toilets as well as kitchens, to reduce health risks and contamination of ground water, and with these systems up to 75% of LPG can be replaced. Larger systems are used at markets and municipal sites, and at these the biogas is cleaned and then used to run small engines to generate electricity for lighting. The largest system is an integrated energy-from-waste plant that processes nearly three tonnes of organic waste per day, including sorted municipal waste and effluent from an abattoir. Here a number of individual digesters are used to manage the different types of organic waste, so that the bacteria in each digester become optimised for the specific waste type. In total, plants installed to date avoid the emission of about 3,700 tonnes/year of CO_2 by replacing LPG for cooking and diesel for electricity generation, as well as preventing the release of methane from unmanaged decomposition of organic matter.

The organisation

BIOTECH was founded as an NGO in 1994 by Mr A Saji Das. It currently employs 25 full-time staff, supported by 200 volunteers. In addition to the biogas work, BIOTECH supplies improved smokeless ovens and stoves, solar lanterns and home lighting systems. The turnover of the biogas work during 2005/06 was approximately £84k.

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Context

Statistical information	
Population (2004)	1,087.1 million
Urban population (2004)	28.5%
GDP per capita US$ (2004)	$ 640
- at purchasing power parity	$ 3,139
Population living on less than $1 a day (2004)	34.7%
Population living on less than $2 a day (2004)	79.9%
Population with access to grid electricity (2000)	43%
Annual electricity consumption per person (2003)	594 kWh
Annual CO_2 emissions per person (2003)	1.2 tonnes
Population undernourished (2001-03)	20%
Population with access to an improved water supply (2004)	86%

Sources: UNDP, World Resources Institute

Kerala is a relatively prosperous state in South India, with a growing middle-class population. Many family members spend part of their working lives overseas. Kerala has a thriving tourist industry with numerous beach resorts, and an increasing number of people come as medical tourists.

Leaving out waste food for animals, which can work adequately in rural areas, is simply not acceptable in this suburban environment, and there is demand for clean and hygienic disposal of waste for homes, institutions and municipalities. Many local councils operate door to door waste collection services, but animals tear open rubbish sacks to get to food waste, and create more litter. The biogas digesters developed by BIOTECH manage organic waste and wastewater at source, and produce significant amounts of clean gas for cooking and other purposes as well.

Technology and use

Biogas systems take organic material into an airtight vessel, where bacteria break down the material and release biogas – a mixture of mainly methane with some carbon dioxide. The biogas can be burned as a fuel and the solid residue can be used as organic compost.

The biogas plants made and supplied by BIOTECH are designed to dispose of organic household and municipal waste and organic wastewater rather than animal dung. BIOTECH has developed standard plants in six different sizes, to serve three different market sectors: domestic (individual households), institutions (schools, hostels, hospitals, hotels) and local councils.

Most domestic plants have a volume of 1 m^3 and produce about 1 m^3 of biogas per day, with a maximum input of 5kg solids and 20 litres organic waste water per day. The digester vessel consists of a gas holder drum, floating over a pre-cast digester tank. The digester tank is usually prefabricated from ferro-cement and sunk into the ground. The gas holder is constructed from Fibreglass Reinforced Plastic (FRP), weighed down with concrete to increase the gas pressure. The pre-cast construction makes it possible for two technicians to construct a plant in about four

hours, so that two to three plants can be constructed in a day. A water seal is used in some domestic models and in all larger systems.

BIOTECH also makes portable digesters that stand on the surface, to allow construction where excavation is impossible or undesirable - for instance where the water table is too high.

The main feedstock for the plants is food waste, but cow dung needs to be used initially to provide a culture of suitable bacteria to get the digestion process started. Food waste is simply mixed with organic wastewater from the kitchen in a bucket and poured into the plant inlet, and no additional water is needed. Biogas gradually collects in the gas holder as the waste decomposes, and a pipe is used to take it to a special biogas stove in the kitchen. A valve is used to open and shut the flow, and a regulator varies the flame. The effluent from the plants is virtually odourless and has a high content of nitrogen, phosphorous and potassium, so it can be used as a garden fertiliser. Nearly 12,000 domestic plants have been installed, serving about 48,000 people. This includes 160 plants which have latrines connected, to avoid contamination of ground water with human sewage.

Biogas plants for schools and hostels range in capacity from about 10 m^3 to 25 m^3 and each serve an average of 200 people. The digester tank is built by excavating a pit, building a brick or ferro-cement wall and then lining it to make it impervious. A drum made of steel coated with FRP (or FRP only for the smaller plants) floats on top and collects the biogas. About 200 institutional plants have been constructed to manage kitchen waste, and a further 22 include latrine connections as well.

On a larger scale, energy-from-waste plants are installed for local councils or fish markets, and are made from one or two 25 m^3 biogas digesters. Organic waste is broken down to a uniform size with a mechanical chopper before it is put into the digester, to speed up the digestion process. If required, water separated from the output slurry can be recycled, by mixing it with the feed material. The biogas is used in a 3 kW engine to generate electricity for lighting the market, and where possible two generators are installed to provide backup for maintenance or repair. It is essential to remove hydrogen sulphide and particulates by ‘scrubbing’ and filtering the gas before it goes into the engine, to prevent corrosion. Because these plants are used in public places the generators and electrical connections must be securely housed in locked cages, accessible only to operators. 19 energy-from-waste projects have been completed and 12 plants are currently under construction.

In Kadakal Grama Panchayat (council) BIOTECH has installed its first integrated waste management system, with a capacity of about one tonne of waste per day. The total quantity of waste generated in Kadakkal Grama Panchayat is around three tonnes per day, which is now all being treated. The municipal solid waste is sorted by hand into wet waste, dry bio-degradable waste, glass, plastics and metal. The wet waste goes into a biogas plants and other materials are sold for recycling. Blood and wash water from a local abattoir is also taken the plant, but uses a separate digester so that the bacteria become optimised for the specific waste type, and a suitable retention time can be established. Overall this biogas plant is processing between two and three tonnes of waste per day, which is close to its maximum capacity. Some of the biogas produced runs an incinerator (the BIOCINARATOR, developed by BIOTECH) for the dry bio waste, and it is also used to generate electricity for lighting.

BIOTECH’s use of pre-fabricated components simplifies the construction of the plants. On-site construction takes only about four hours (instead of four days) and semi-skilled or unskilled masons can install the units easily.

The total capacity installed by BIOTECH so far is 16,000m^3, split 81% for domestic users, 16% for institutional users, and 3% for energy-from-waste schemes.

How users pay

£1 = Rs 85 Indian Rupees [March 2007]

A domestic biogas plant costs about Rs 9,500 or £110. The national Ministry of Non-conventional Energy Sources (MNES) offers a subsidy of Rs 2,700 for each domestic plant up to 10 m^3 capacity, and the local and district panchayats (councils) provide further subsidies - typically Rs 2,700 in urban areas and Rs 3,500 in rural areas. The purchasers pay the remainder directly. The MNES subsidy is paid to the beneficiary through BIOTECH after a government official has inspected the plant. Although MNES subsidies are likely to be phased out, the value of the biogas plants for waste disposal means that panchayat support is likely to continue.

Some people have chosen to purchase a more expensive 'premium' plant with ceramic tiles around the pit and a coloured gas drum.

The integrated waste management plant costs Rs 3,000,000 (£35,300) of which Rs 120,000 came from MNES and some from the local and district panchayats. BIOTECH provides some capital, and charges an annual operating fee to run the plant.

Training, support and quality control

BIOTECH staff visit each new customer every three months for two years in order to ensure that the plant is running smoothly.

BIOTECH manufactures all the plants in its own workshops to a high standard. The details of all plants are recorded so that BIOTECH is eligible for the subsidy from MNES. The oldest plant in use is over ten years old and was giving satisfactory service when an Ashden assessor visited. There have been occasional minor problems with gas pipes blocked (or chewed through by rats), water condensing in pipes, and broken tap fittings. These were fixed quickly by BIOTECH staff.

Benefits

For most domestic users, the main benefit of a BIOTECH plant is the easy, hygienic disposal of food waste. This avoids the smells, pests and health hazard of throwing food out for animals to eat. Even where municipal waste is collected, animals tend to tear open rubbish bags to get to food material, so the BIOTECH system gives a cleaner disposal route. Operators of institutional plants are pleased with the absence of odour, which was unpleasant for both them and their neighbours. For the markets and councils, the removal of food waste and the associated health risks is a great advantage.

In homes and institutions, cooking is always started on the biogas stove. This can be used for typically two hours from the gas produced during the previous day, and the pot is simply moved to the LPG stove when the biogas runs out. A typical family normally uses a standard cylinder containing 14 kg of LPG costing Rs 380 in 25 – 30 days, or about 168 kg per year. Biogas replaces about 50% of this, or about 84 kg per year, and thus saves the family about Rs 2,280per year. This means that the family can pay back their contribution to the cost of the plant in about three years, and more quickly if they collect extra food waste from shops to increase their biogas production. The time saved in exchanging LPG cylinder is also appreciated. Institutional plants with latrines attached replace between 50 and 75% of their LPG use, because of the additional biogas production from the sewage waste. Biogas is safer than LPG for cooking, because it cannot be lit accidentally by a spark. LPG is common in urban areas, but in rural areas most cooking is done using firewood or kerosene.

The effluent or residue in the biogas plant makes good fertiliser which results in higher food production. Comments from users have included remarks like: 'My coconut tree gives more coconuts' and 'The plants grow much better and give more flowers.'

The total rate of biogas production from all installed plants is estimated to be about 16,000 m^3/day, which replaces the equivalent of about 3.7 tonnes/day or 1,400 tonnes/year of LPG and diesel. The plants therefore directly avoid the emission of about 3,700 tonnes/year of CO_2, with further savings from the reduction in methane production from the uncontrolled decomposition of waste, and from the transport of LPG.

The manufacture, installation and maintenance of the biogas plants has generated a significant amount of employment This is estimated at 13 days for each domestic plant, 55 days for each institutional plant and 80 days for each waste to electricity plant. An estimated total of 500 days/year is required for maintenance and servicing and 140 days/year for operation of the institutional plants

Potential for growth and replication

There is considerable demand for BIOTECH plants and the main constraint to growth is the government subsidy. Each year BIOTECH must submit a proposal to the government outlining the number of new installations they plan and the amount of subsidy they would like. They usually receive an amount that enables them to carry out 50% of the subsidised installations they planned.

BIOTECH is experiencing an increasing demand for domestic scale systems. It can supply a plant within two to three days of it being requested providing the finance is available. With the larger systems, the provision of subsidies is the main limiting factor. Panchayats have to work through a budget process each year and allocate money to capital projects such as biogas plants, which can take some time.

The technology could be used in many other countries. In rapidly growing urban areas, the safe disposal of organic waste at source is important for hygiene and cleanliness, and the value of the gas produced is significant for households and institutions. However, the greater potential is possibly at the municipal level, where there are serious public health risks from large volumes of organic waste, including pollution of water supplies. To work effectively the plants need an average ambient temperature above 30C throughout the year – but it is in countries with these high temperatures that the health problems from unmanaged waste are the most serious.

Management, finance and partnerships

Mr A Saji Das established BIOTECH, and remains actively involved in the development of the organisation. BIOTECH currently has 42 full-time staff and also employs180 technicians on a piece rate basis. BIOTECH participates in symposia, seminars, exhibitions, and demonstrations at state and national level to promote biogas technology. The Ministry of Non-conventional Energy Sources provides vital assistance in the form of subsidies for plant installations.

This report is based on information provided to the Ashden Awards judges by BIOTECH and findings from a visit by one of the judges to see their work in India.

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